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FACTORS AFFECTING AGRICULTURAL TRADE: AN INTERCOUNTRY EMPIRICAL INQUIRY

by

Thomas L. Vollrath

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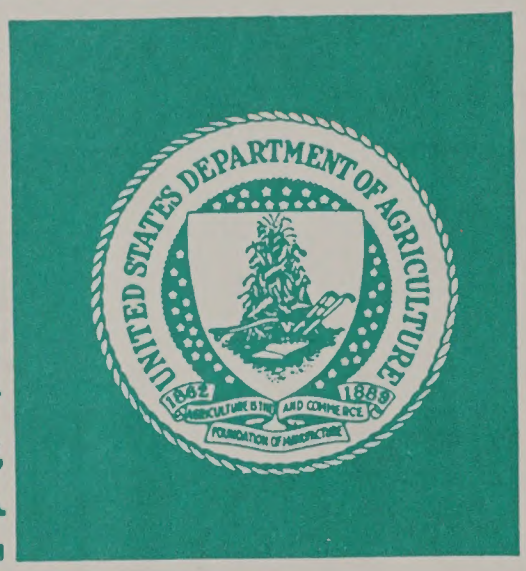

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Thomas L. Vollrath

March 1983

Agricultural Development Branch
International Economics Division
Economic Research Service
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ABSTRACT

The relationship between economic development and agricultural trade was evaluated quantitatively using 25 years of intercountry data. Econometric models were used to identify the importance of developmental factors affecting agricultural trade. In addition, descriptive statistics were generated enabling net exporting countries to be differentiated from net importing countries. The relevance of both the factor proportion and the technological explanation of comparative advantage was verified for agriculture. Implications for U.S. policy were drawn from the empirical analyses and integrated into a larger body of knowledge concerning the interrelation among agricultural development, agricultural trade, and general economic performance.

Keywords: Agricultural trade, agricultural development, economic development, comparative advantage, induced technological change.

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PREFACE

There was a marked and unprecedented rise in the trade of agricultural commodities in the 1970's. The increase was particularly dramatic in 1973 and 1974 at which time the real (1970) value of agricultural trade rose to $88 billion per year, an average annual increase of 20 percent from the previous two years. While the expansion was unusually strong during these two years, growth throughout the decade was also impressive. The real value of agricultural goods flowing through international markets increased from $71 billion in 1971 to $96 billion in 1980, representing an increase of 35 percent during the decade.

The structure of world agriculture was altered by the expansion in agricultural trade during the 1970's. Aggregate demand for agricultural commodities outstripped available supplies and caused real prices to rise. The increase in demand was caused by the forces underlying economic growth and by exogenous shocks to the international trading system.

The adoption of relatively flexible international exchange rates in the early 1970's contributed to a realignment of commodity prices, effectively eliminating many distortions which had accumulated under the fixed system of exchange. During this process, it appears that (with the exception of oil related industries) resource prices became valued more closely to their true opportunity costs; and the price of agricultural goods increased relative to most other commodity prices, stimulating agricultural production and trade.

Another factor affecting agricultural trade were shortfalls in agricultural production attributable to bad weather in 1973 and 1974 in the Soviet Union and in certain areas of the developing world, most notably countries in South Asia and in the Sahelian zone in Africa. It was during the two "crisis" years that the most dramatic rate of increase of agricultural trade in the decade occurred. Moreover, trade linkages were established at this time between food deficit countries and export suppliers that facilitated the flow of agricultural goods in subsequent years. In Africa, for instance, both commercial and concessional food imports have risen to and remained at historic levels largely due to these established institutional linkages, suggesting continued high agricultural imports to this area in the future.

Agricultural imports to the Union of Socialist Republics (USSR) and People's Republic of China (PRC) from the rest of the world increased substantially in the 1970's due to changing political considerations; namely, a conscious decision to upgrade diets in Russia and the emergence of China as a more active participant in international markets. The real value of agricultural imports more than doubled from $2.1 billion to $4.8 billion annually in the Soviet Union and increased 70 percent to over $1 billion in the PRC between the mid-1960's and the end of the 1970's. Based upon recent historical trends, it appears that Russia and China represent important outlets for agricultural commodities in the 1980's; that is, provided that the political environment is conducive to the exchange of agricultural commodities between these two countries and the rest of the world.

The greatest rate of increase in net agricultural imports between the 1960's and the 1970's occurred in rapidly growing middle income countries such as Taiwan, South Korea, Iran, Tunisia, Portugal, and Spain. The increase in the demand for agricultural commodities in these countries outpaced growth in domestic production because of large increases in per capita income (from relatively low absolute levels) and because of intersector shifts in the allocation of national resources. (In most of these countries, South Korea being an exception, farm labor moved to employment in the nonagricultural sector where, evidently, higher real wages could be earned). The increase in the demand for agricultural imports is likely to sustain itself in the rapidly growing middle income countries 1) because of good prospects for continued economic growth in which production becomes increasingly specialized and 2) because these countries are characterized by accelerated growth in the demand for fruits, vegetables and livestock products and consequent growth in the derived demand for feedgrains.

It is not clear whether the increase in agricultural trade, featured in the 1970's, is a transitory phenomenon or part of a long run enduring trend. Dramatic changes always entail certain adjustments which may not have had sufficient time to work themselves out. Among the initial beneficiaries of the surge in world demand for agricultural goods, for example, were farmers who either invested heavily in agriculture and/or adopted more efficient technologies. In subsequent periods, the benefits of technological change and possible overinvestment in agriculture are

often transferred to the consumer, when producers are confronted with a cost-price squeeze such as is being witnessed today.

The study which follows is designed to gain a better understanding of the fundamental relationship between factors underlying economic development and agricultural trade. Knowledge about the economic structure of world agriculture and how it affects agricultural trade is essential to sound analyses of U.S. trade policy.

INTRODUCTION

The primary objective of this research is to generate information about the relationship between economic development and agricultural trade so that the importance of factors which account for differences in agricultural exports and agricultural imports among countries can be identified. Development is portrayed from analyses of supply and demand attributes related to intercountry stocks of land, labor, capital, and the size and rate of growth of population and wealth. These attributes and their interrelationships are both determinant and characteristic of the development process and are also related to open market acquisitions and sales of agricultural commodities.

The general development process is considered to be a long run phenomenon. Over time changes do occur in basic relationships, but not often. An interesting issue which this research addresses is to what extent, if any, has the constellation of complex interelationships between agricultural development and trade changed concomittantly with the expansion in the international exchange of agricultural commodities in the 1970's.

Some interesting patterns concerning the development process and the relationship between agricultural and economic development and agricultural trade emerge on the basis of cross-sectional and time-series based descriptive statistics. Other aspects are more effectively revealed by taking into account, within a simultaneous framework, both agricultural trade and factors that affect the agricultural and economic development process.

The economic model is derived from comparative advantage and general equilibrium theory. The empirical model is based upon the concept of the metatrade function which transcends national boundaries. Longrun average net foreign agricultural trade, defined as the difference between exports and imports, is regressed on factors hypothesized to determine domestic production and domestic consumption of agricultural commodities.

The econometric analyses and descriptive statistics presented in this report are based on 15 years of intercountry data (1963-77) which usually have been averaged at 5-year intervals (1965, 1970, and 1975) in order to reduce stochastic errors. Fifty-seven countries, consisting of poor, middle, and high income nations, were selected to represent a sample of countries at different stages of development. 1/ (These countries contain, collectively, over 80 percent of the free world's arable and permanent cropland). The development process is simulated by movement up the income scale across this sample of countries. In general, intercountry differences provide enough variation in the variables to obtain meaningful statistical estimates.

This report is organized in three parts. The first section contains a simple descriptive analysis of the international cross-section and time-series data which are presented at five year summary intervals in the Appendix.

1/ East Pakistan seceded from Pakistan in 1972. The data do not, however, reflect this division. Hence, the figures for Pakistan between 1973-1977 represent West Pakistan and Bangladesh. A consistent definition for Pakistan was needed throughout the time period of the analysis in order not to bias statistical tests and empirical comparisons.

A more sophisticated analysis and interpretation of the data is the subject of the second section in which relevant economic theory and statistical models are discussed and empirical results are examined. In this section, inferences are made with respect to the relative importance of the agricultural resource endowment, modern agricultural inputs acquired from the industrial sector, and educational and research and development (R & D) factors affecting domestic production, consumption, imports, and exports of agricultural commodities. Moreover, the sensitivity of the foreign exchange balance to changes in factor usage and to changes in the demand for agricultural goods is estimated quantitatively.

In the last section, implications are drawn for U.S. trade and development policies vis-a-vis low, medium, and high income countries. The basis for these conclusions are derived from the more general findings emanating from this research as well as from a synthesis of particularly pertinent knowledge accumulated in the recent literature.

DESCRIPTIVE ANALYSIS

It is apparent, from an assessment of data in the sample, that most countries experienced real increases in both agricultural exports and imports during the 1970's, irrespective of whether they were classified as net importers or net exporters of agricultural commodities. This may be attributable, in part, to increases in the relative price of agricultural to most nonagricultural goods. Moreover, it is suggestive of greater specialization in agricultural production, a not unexpected result of trade expansion.

The impact on an individual country's foreign exchange balance of increases in agricultural exports and imports varied considerably. Countries experiencing the greatest positive gains in net agricultural trade between the midsixties and the midseventies (namely, the United States, Australia, Brazil, Argentina, New Zealand, Thailand, and Malaysia) are the same countries characterized as having the largest 1973-77 average net agricultural export balance. Moreover, three of these seven countries (the United States, Brazil, and Malaysia) experienced the greatest rate of positive growth in net agricultural trade of all of the net exporting countries. The conclusion which may be drawn from these findings is that countries, which had established favorable agricultural trade balances in the 1960's, were the primary beneficiaries of revenue growth attributable to agricultural trade expansion in the 1970's.

A similar pattern emerged among the largest net agricultural importers (namely, Japan, West Germany, Great Britain, Italy, Taiwan, Belgium, Switzerland, Iran, Sweden, Spain and South Korea); this is to

say, 1) there is a close ranking between these countries and those experiencing the greatest absolute increases in net agricultural imports and 2) several of these countries (most notably Iran and Taiwan and, to a lesser but significant degree, South Korea and Spain) have experienced the most rapid rate of growth in net agricultural imports. These findings suggest that the more important net importers became increasingly reliant upon the foreign market to supply their agricultural requirements in the 1970's; and that they paid for these imports by increasing production and exporting nonagricultural goods for which they (presumably) possessed a comparative advantage.

Some Determinants of Agricultural Trade

An improved understanding of the relationship between economic development and agricultural trade can be obtained by examining the question of why some poor, rich, and middle income countries have positive, and others, negative balances of agricultural trade. The agricultural resource endowment is obviously a primary determinant of the extent to which countries beget surpluses in agricultural production which are then exported to generate foreign exchange or experience deficits in domestic production importing large quantities of needed agricultural goods and consuming foreign exchange in the process. A second major determinant is the need and ability of a country's citizenry to purchase agricultural imports in response to preferred consumption of high quality foodgrains and livestock products.

Demand considerations, which characterize the development process, such as the size and rate of growth of a country's population and the wealth of its citizens, affect purchases on the open market. The

importance of ability to pay for imports is demonstrated by the fact that the dozen countries whose net agricultural imports are valued the highest (in the 1975 sample) are among the fastest growing and wealthiest. Moreover, the fact that over one-half the population in our sample is located in the Third World--countries whose real (1970) per capita incomes (adjusted by purchasing power parities) are less than $2500 per annum and population grows at the relatively high yearly rate of 2.5 percent--is evidence of strong pressure to increase agricultural imports and decrease agricultural exports in many countries in order to feed an expanding population even if per capita income levels remain persistently low. 2/

Country supply attributes, such as resource stocks and levels of technology, are determinants of agricultural production and the flow of agricultural trade. Some of the dynamics occurring in world agriculture become more understandable after having examined changes in the availability and use patterns of agricultural inputs among different groups of countries.

2/ In response to the international comparison of income problem, Kravis, Heston, and Summers developed a system for estimating real GDP per capita that accounts for differences in purchasing power among currencies. See, Irving B. Kravis, Alan W. Heston, and Robert Summers, "Real GDP Per Capita For More Than One Hundred Countries," The Economic Journal 88 (June 1978): 215-241. Subsequently, these researchers derived estimates of real GDP per capita that were adjusted by purchasing power parities for many countries over time. These estimates of real income are used in this study. See, Robert Summers, Irving B. Kravis, and Alan W. Heston, "International Comparisons of Real Products and Its Composition: 1950-1977," Review of Income and Wealth (March 1980): 19-66.

Over one-half of the net exporting countries either expanded their agricultural land base and/or increased their agricultural labor force more than 15 percent between the 1965 and the 1975 period. All of these countries, with the exception of Australia, can be characterized as being in the early stages of economic development in which per capita incomes are relatively low and in which agriculture represents a source of growth because of the unrealized potential of the natural resource endowment (land and labor) bestowed by Nature. The fact that 70 percent of the countries with real per capita incomes below $2500 earn more foreign exchange than they spend by trading agricultural commodities on the international market provides empirical justification for the statement that agriculture is, indeed, a primary growth industry in the developing world.

By contrast with the net exporters, land use decreased more than 5 percent and/or the agricultural labor force diminished greater than 30 percent within the same time period in one-half of the net importing countries; all of whom, incidentally, are the relatively high income countries in Europe and Japan. Moreover, substantial declines in the agricultural use of both land and labor were experienced by one-fourth of the net importers. These findings indicate that in Japan and some of the older industrialized countries, primary resources (particularly labor) are leaving agriculture for employment in other sectors, suggesting that economic activities are becoming increasingly specialized.

Land and labor are, of course, not the only factors of production in agriculture. Considerable technological differences exist among countries. It is, therefore, instructive to evaluate the availability

and/or use patterns of inputs, such as fertilizer and machinery, supplied from the industrial sector and used to increase agricultural productivity.

Fertilizer and machinery are, to a certain extent, substitutes for land and labor respectively. An examination of the tractor-horsepower-to-labor and the fertilizer-to-land ratios for a selected set of countries in 1965 and 1975, graphically illustrated in Figure 1, demonstrates that substantial differences exist among countries in both the direction and the intensity of modern input usage. The data indicate that countries with relatively low land-labor ratios tend to have higher fertilizer-land than machinery-labor ratios and countries with relatively high land-labor ratios have higher machinery-labor than fertilizer-land ratios. Fertilizer is used relatively more intensively than machinery in countries such as Japan, Indonesia, Phillippines, South Korea, and Taiwan where land is scarce relative to labor. Likewise, in countries characterized as being land abundant relative to labor in, for instance, the United States, Argentina, Australia, and Canada, machinery is used relatively more intensively than fertilizer.

In addition to identifying the direction which technical change takes, the data on modern input usage underscore the large technological gap separating the developing countries from the more advanced countries (including South Korea and Taiwan). The average fertilizer application per unit of land, characteristic of the eight countries using chemical plant nutrients most intensively (in 1975), is 70 times the rate of the eight countries using the least nutrients. Horsepower utilization per labor unit characteristic of the eight countries using machinery most intensively is over 1000 times the horsepower utilization per labor unit of the eight countries using machinery least intensively. Machinery is

most heavily used in the developed countries; particularly in the United States, Canada, Australia where land is abundant relative to labor, and in West European nations where rural wage rates are relatively high inducing mechanical equipment to be substituted for labor. Fertilizer is used most intensively in small developed countries such as the Netherlands, Belgium, Ireland, West Germany, and Switzerland where land is severely limiting, as well as in three of the most rapidly growing countries, namely South Korea, Japan, and Taiwan.

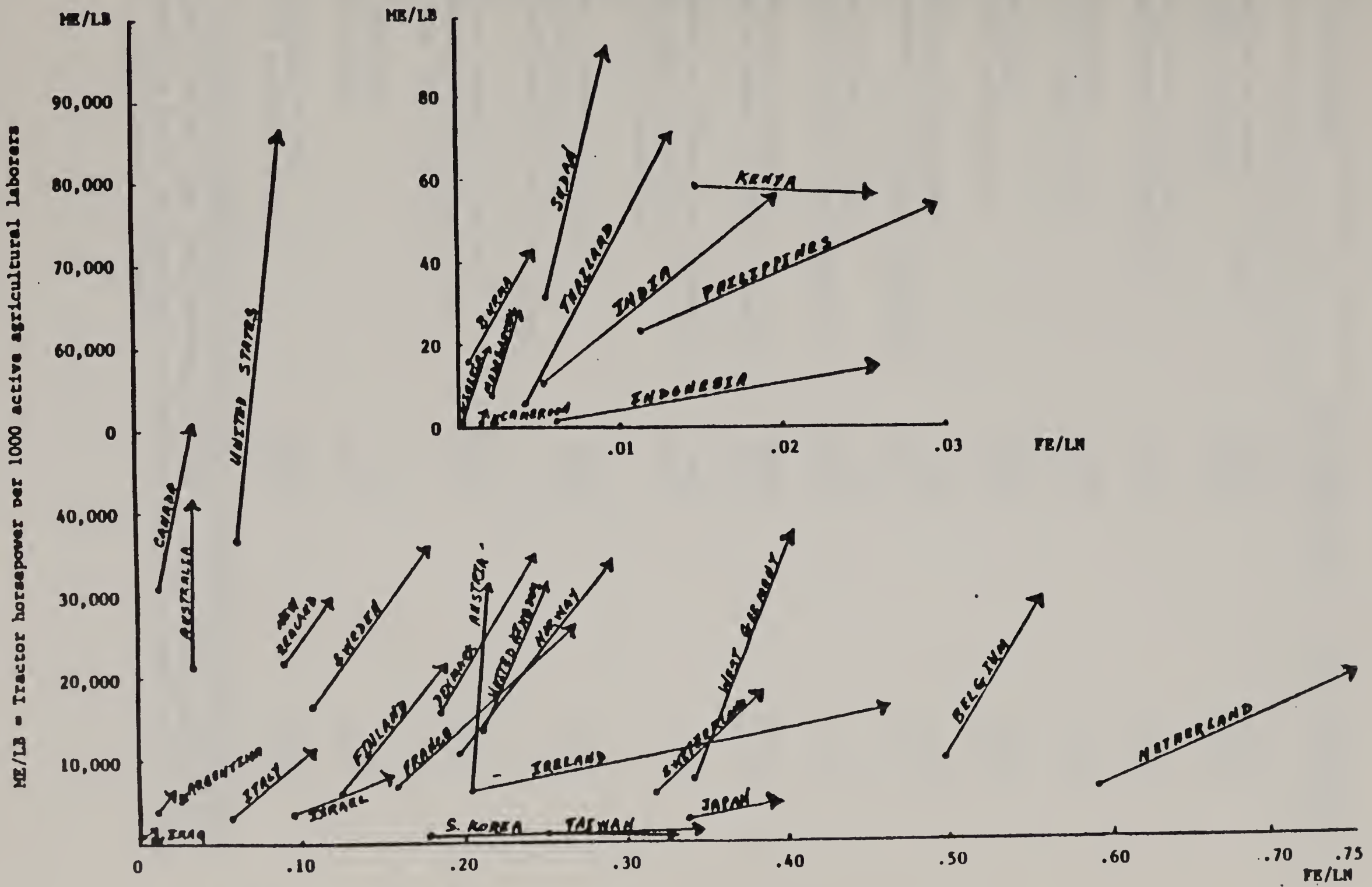
These findings underscore a diverse and changing pattern of agricultural technology among countries. Mechanization has been a primary source of agricultural growth in many developed countries. Continued rapid increases in machinery reflects, together with declines in land and labor, basic structural change still occurring in Western Europe.

In the developing world, fertilizer has been a more important factor influencing growth than mechanization. Use of both industrialized inputs are increasing at a faster rate, however, than increases in either land or labor, providing evidence that structural transformation is taking place and that agriculture is a growing and dynamic sector in the Third World.

Comparisons Between Net Importing and Net Exporting Countries

A comparison of the magnitude and variability of attributes characterizing the development process for different groups of traders helps to differentiate between net agricultural exporting and net agricultural importing countries, Table 1. Two additional attributes, heretofore not mentioned, are added to the analysis at this point. One

Figure 1: Intercountry cross-section comparisons of changes in tractor horsepower per worker and in fertilizer plant nutrients per hectare of agricultural land, 1965-1975



HE/LB = Tractor horsepower per 1000 active agricultural laborers

FE/LN = Metric tons of ($N + P_2O_5 + K_2O$) per hectare of arable and permanent cropland

Table 1: Comparative Attributes Between Different Groups of Agricultural Traders a/

Attributes	Net Exporters	Net Importers
Arable Permanent Cropland (1000 hectares)	21500 (1.9)	5900 (1.0)
Agricultural Labor (millions of laborers)	9 (2.8)	2 (1.2)
Fertilizer (1000 metric tons)	750 (3.3)	790 (1.4)
Machinery (1000 horsepower)	8300 (3.9)	9400 (1.5)
Technical Education (number of college graduates)	970 (2.4)	910 (2.2)
Fertilizer Intensity (tons of fert. per hectare)	.07 (1.8)	.18 (.8)
Machinery Intensity (horsepower per 100 laborers)	6400 (2.2)	9000 (1.0)
Technical Education Intensity (college graduates per million laborers)	460 (1.9)	510 (.8)
Real Income per Capita (adjusted by 1970 purchasing power parities)	1300 (.9)	2300 (.5)
Gross Domestic Product (adjusted by 1970 purchasing power parities	55000 (3.1)	61000 (1.3)
Population (millions)	45 (2.1)	24 (1.1)
Capacity to Pay (1970 million dollars)	2900 (2.5)	7200 (1.3)

a/ Means and associated coefficients of variation (within paranthesis) based upon data between 1963-77. During this period, 35 countries were, on average, net agricultural exporters and 22 were net agricultural importers.

is technical education in agriculture, a technology type variable that bears directly upon production and hence supply. The other is a demand variable which denotes a country's capacity to pay for imports in terms of the availability of foreign exchange.

The net agricultural importing countries have, on average, considerably higher per capita income and more foreign exchange than the net agricultural exporters. This does not mean, however, that agricultural activity is less profitable than industrial enterprise. The relatively high coefficients of variation characterizing the net agricultural exporters' demand attributes attests to the comparatively wide range of countries classified as exporters. This is confirmed by the fact that many net agricultural exporters are in the early stages of development and others are among the most advanced countries characterized by a well-endowed natural resource base and/or a history of considerable capital investment in agriculture.

The group of net agricultural exporting countries have a much more richly endowed agricultural resource base than the group of net agricultural importing countries. The average land base for the 35 countries which had a positive net agricultural trade balance over 15 years was 3.5 times the average land base of the 22 countries which had a negative balance. Moreover, the net exporters' agricultural labor force was 4.5 times that of the net importers' labor force.

The group of net importing countries endeavored to compensate for their relatively scarce natural resource base by substituting capital for land and labor. The quantity of fertilizer and tractor horsepower used in production as well as the number of college graduates trained in agriculture did not differ appreciably, on average, between the net

exporters and the net importers. The difference in the capital/labor and the capital/land ratios, however, was striking. This was particularly the case for fertilizer--the net agricultural importers applied 2.5 times the amount of fertilizer per unit of land than did the net exporters.

These results are average relationships that mask differences among countries within each of the two groupings. Individual country attributes often deviate widely from the average. The variation within the net agricultural exporter group is especially great, being twice as large as the net importers.

ECONOMETRIC ANALYSIS

The theoretical foundation underlying the economic modeling effort is fundamentally linked to the theory of comparative advantage. The Ricardian tradition of comparative costs and the Heckscher-Ohlin theory of factor endowments represent the two basic perspectives of trade. 3/ The focus of the classical Ricardian model is on relative costs and technology differences. The Heckscher-Ohlin explanation of comparative advantage is based upon differences in factors proportions, with technology assumed to be stable and universally available.

Empirical studies designed to explain patterns of actual trade based upon the theories of comparative advantage have had only qualified success. A primary shortcoming of the Ricardian theory is that demand considerations are ignored. Difficulties with the Heckscher-Ohlin theory are that it does not address the impact of natural resources, education, and research; nor does it allow for factor intensity reversals associated with the availability of different technological options and relative factor prices among countries.

Kenen has developed a more general framework that integrates growth with trade and promises to generate superior empirical results than

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3/ David Ricardo, Principles of Political Economy and Taxation. ed. E.C.K. Gonner (London: George Bell & Sons, 1903); Eli Heckscher, "The Effect of Foreign Trade on the Distribution of Income," Ekonomisk Tidskrift 21 (1919): 497-512; and Bertil Ohlin, Interregional and International Trade (Cambridge: Harvard University Press, 1933).

either of the two conventional theories of comparative advantage. 4/ He assumes that each country has a fixed natural endowment consisting of stocks of land and labor which are inert; that is, until they are improved by acts of investment. Capital is characterized as a secondary factor of production inherently different from but complementary to the two primary factors--land and labor. The capital investment process is viewed as evoking finite service flows from land and labor, the two primary inputs of production.

The two conventional theories of comparative advantage are brought together in Kenen's framework. Kenen's perception of a fixed natural endowment consisting of two primary factors of production conforms to the Heckscher-Ohlin view, except that the focus is on land and labor rather than labor and capital. In addition, Kenen's allowance for capital investments which generate service flows from the two factor resource endowment enable technological differences to exist among

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4/ Peter B. Kenen, "Nature, Capital, and Trade," Journal of Political Economy 73 (October 1965): 437-460; and Peter B. Kenen, "Toward a More General Theory of Capital and Trade," in The Open Economy, ed. Peter B. Kenen (New York: Columbia University Press, 1968): 100-123.

countries, a characteristic of the Ricardian model lacking in the conventional Heckscher-Ohlin version. 5/

Modern extensions to the theory of trade have resulted in the "neotechnology" explanation of comparative advantage in which technological change is taken into account and the "neofactor proportions" explanation of comparative advantage which allows for factors other than labor and capital (such as land, skilled labor, and other natural resources) and which also permits factor reversals. 6/ A complete treatment of comparative advantage includes elements of both

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5/ Findlay has developed an alternative way to account for factor accumulation by incorporating, within the context of the Heckscher-Ohlin framework, dynamic determinants and a third nontraded capital goods. See, Ronald Findlay, "Factor Proportions and Comparative Advantage in the Long Run," in International Trade: Selected Readings, ed. Jagdish N. Bhagwati (Cambridge: MIT Press, 1981). pp. 68-75.

6/ Ronald W. Jones, "Factor Proportions and The Heckscher-Ohlin Theorem," Review of Economic Studies 24 (1956-1957): 1-10; Peter S. Heller, "Factor Endownment Change and Comparative Advantage: The Case of Japan, 1956-1969," Review of Economics and Statistics 58 (August 1976): 283-292; Michael Hood, "An Empirical Investigation of The Heckscher-Ohlin Theory," Economica 34 (February 1967): 20-29; Morris Teubal, "Toward a Neotechnology Theory of Comparative Costs," Quarterly Journal of Economics 89 (August 1975): 414-431; S.J. Turnovsky, "Technological and Price Uncertainty in a Ricardian Model of International Trade," Review of Economic Studies 41 (April 1974): 201-217; Alan Deardorff, "The General Validity of the Law of Comparative Advantage," Journal of Political Economy 88 (October 1980): 941-957; Robert L. Thompson and Philip C. Abbott, "On the Dynamics of Agricultural Comparative Advantage," paper presented at USDA-Universities International Agricultural Trade Research Consortium Meeting, St. Louis, June 24-25, 1982, (typewritten). Bagicha S. Minhas, An International Comparison of Factor Costs and Factor Use. Amsterdam: North-Holland Publishing Co, 1963; Kym Anderson, "Changing Comparative Advantage in Agricultural Theory and Pacific Basin Experience," paper presented at Workshop on Australian Agriculture and Newly Industrializing Asia at Australian National University, Canberra, July 17-18, 1980, (typewritten); Jaroslav Vanek, "The Natural Resource Content of Foreign Trade, 1870-1955, and the Relative Abundance of Natural Resource in the United States," Review of Economics and Statistics 41 (May 1959): 146-153; Seev Hirch, "The Product Cycle Model of International Trade--A Multi-Country Cross Section Analysis," Oxford Bulletin of Economics and Statistics 37 (1975): 305-317; Morris Teubal, "Comparative Advantage and Technological Change: The Learning By Doing Case," Journal of International Economics 3 (1973): 161-177; and Roger W. Klein, "A Dynamic Theory of Comparative Advantage," American Economic Review 63 (March 1973): 173-184.

extensions. Hufbauer and Hirsch integrate the neotechnology with the neofactor proportion explanation by basing the concept of comparative advantage upon the interaction between factor endowment (a country characteristic) and factor intensity (an industry characteristic). 7/ Their approach is rendered consistent with the Kenen framework in this study by relating neotechnology to capital.

Both the conventional theory of comparative advantage and its modern extensions place emphasis on the production structure. General equilibrium theory also addresses consumption. A standard neoclassical view of agricultural trade, for example, highlights the interrelationship between foreign and domestic supply and demand for agricultural products. There are major difficulties, however, in trying to provide direct empirical content to a general equilibrium model when the focus is on total agricultural trade rather than commodity specific trade.

Economic Model

Net trade is a function of demand and supply:

$$T = f(D,S)$$

Actual net agricultural trade is equivalent to domestic production minus domestic consumption and net changes in domestic stocks. A positive value for net trade indicates that a country is a net agricultural exporter which produces more than it consumes after netting out changes

7/ Seev Hirsch, "Capital or Technology? Confronting The Neo-Factor Proportions and Neo-Technology Accounts of International Trade," Weltwirtschaffliches Archiv 110 (1974): 535-563; and G.C. Hufbauer, "The Impact of National Characteristics and Technology on The Commodity Composition of Trade in Manufactured Goods," in The Technology Factor in International Trade, ed. R. Vernon (New York: Colombia University Press/NBER, 1970): 145-232.

in stocks. Conversely, a net importer of agricultural commodities, depicted by a negative value for net trade, produces less than it consumes following net stock changes.

A viable approach for analyzing the structure of world agricultural trade is to estimate an aggregate net agricultural trade function, similar in nature to the agricultural production function first used by Hayami and Ruttan to establish general relationships between inputs and outputs. Hayami and Ruttan advanced the understanding of long run agricultural supply by estimating a metaproduction function across countries and, thereby, identifying the importance of supply shifters in world agriculture. 8/

8/ The metaproduction function is based upon the theory of induced innovations. An attempt to reconcile Hayami and Ruttan's original definition of the induced innovation process, using the concept of the metaproduction function, with that of a revised definition is as follows: In the short run, in which substitution among inputs is circumscribed by the rigidity of existing capital and equipment, production relationships can be described by an activity with relatively fixed factor and factor-product ratios. In the intermediate run, in which the constraints exercised by existing capital disappear and are replaced by the fund of indigenously available technical knowledge, including all alternative feasible factor-factor and factor-product combinations, production relationships can be adequately described by the neoclassical production function. In the long run, in which technology may be borrowed from the most efficient countries and adapted to suit the factor endowment of the recipient country, production relationships, given the current state of scientific knowledge, can be described by the metaproduction function at the technological frontier. In the secular period of production, in which constraints are further relaxed so as to admit potentially discoverable production possibilities, production relationships can be described by Ahmad's "innovation possibilities curve" corresponding to the appropriate research budget that identifies all potential technologies which might be invented at the scientific frontier. See, Yujiro Hayami and Vernon W. Ruttan, Agricultural Development: An International Perspective (Baltimore: The Johns Hopkins University Press, 1979), pp. 82-83; Vernon W. Ruttan, Hans P. Binswanger, Yujiro Hayami, William W. Wade, and Adolf Weber, "Factor Productivity and Growth: A Historical Interpretation," in Induced Innovations: Technology, Institutions, and Development, eds. Hans P. Binswanger and Vernon W. Ruttan (Baltimore: The John Hopkins University Press, 1978), p. 46; and Syed Ahmad, "On the Theory of Induced Inventions," Economic Journal 76 (302) (June 1966): 344-357.

Thompson and Schuh have explored the theoretical basis for the existen of a metademand function. 9/ They contend that such a function could be estimated with cross-country data in the same way the metaproduction funct has been estimated, and, in an analogous way, lead to improved understandi of the long run conditions of demand.

Valentini and Schuh were the first to estimate a meta function for trad that transcends national boundaries in an attempt to gain an improved understanding of economic factors that affect the pattern of trade in agricultural commodities among countries. 10/ The second of two kinds of econometric models specified in this study is quite similar to their pioneering effort. Some differences exist, however, with respect to level aggregation and variable coverage. Furthermore, more recent as well as improved data were used.

The metatrade function expresses agricultural production in terms of the inputs used in the generation of domestic output. Consumption is represente by a vector of variables that affect agricultural demand. Thus, net agricultural trade is simply described as a function of demand and supply considerations:

$$NT = f[D(X_1, X_2, X_3 \ldots X_n),\ S(Y_1, Y_2, Y_3 \ldots Y_m)]$$

Statistical Models and Empirical Results

Initially, a simple metatrade model was specified in order to examine the extent to which fundamental production and consumption determinants

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9/ Robert L. Thompson and G. Edward Schuh, "A Metademand Function?" Contributed paper presented at the annual meetings of the American Agricultural Economices Association, Ohio State University, August 10-13, 1975.

10/ Valentini and Schuh tested the hypothesis that the capability to produce and absorb new production technology is an important element determining comparative advantage in agricultural products. Their

could explain variations in the net exchange of agricultural commodities. This model (estimated for three time periods, 1965, 1970, and 1975) contains only two independent variables--1) a supply variable denoting factor proportions, the land-labor ratio, and 2) a demand variable, per capita income:

$$NT = b_o + b_1 LL + b_2 YP + \xi$$

where

NT = Value of net agricultural exports expressed in constant 1970 million dollar units.
LL = Hectares of arable and permanent cropland per 100 active agricultural laborers.
YP = Real (1970) income per capita adjusted for internal differences in purchasing power parities.
ξ = Error disturbance term.

The land-labor ratio (LL) represents the natural resource endowment in agriculture. It was included in the equation on the basis of the importance of relative factor proportions as an explanation for trade in agriculture. The second independent variable, real income per capita (YP) was included in the model to account for domestic demand and general equilibrium effects.

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empirical results supported this hypothesis, providing evidence that technological factors are associated with international comparative advantage in agriculture. See, Rubens Valentini, "Technology and International Trade in Agricultural Products: A Test of Some Hypotheses," PhD. dissertation, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana (1974); and Rubens Valentini and G. Edward Schuh, "The Meta-Production Function, Technology and Trade in Agricultural Products," contributed paper presented at Econometric Society Annual Meetings, San Francisco, December 1974, (typewritten).

Statistical estimation of the simple model consisted of performing linear regression using ordinary least squares procedures. The empirical results, presented in Table 2, suggest that supply and demand considerations are important explanatory factors of variations in net agricultural trade; note that YP and LL have highly significant t-statistics. Moreover, the empirical results demonstrate that there has been a structural change in agriculture in the mid-1970's. This is indicated by the doubling in magnitude of the coefficients for YP and LL in 1975 from their estimated values in 1970 and 1965.

Countries with relatively high land-labor ratios have been among the primary beneficiaries of the structural changes which have taken place in world agriculture. In the sample of 57 countries, Australia, United States, Canada, and Argentina have the highest land-labor ratios. The

Table 2—Simple Net Agricultural Trade Equations
(1965, 1970, 1975)

Variable	1965	1970	1975
C	276.94	430.53	934.54
LL	.05247	.04564	.1154
	(4.27)	(4.07)	(4.94)
YP	-.4585	-.4827	-1.02
	(-3.40)	(-3.81)	(-3.76)
N	57	57	57
R^2	.25	.25	.30

Note: Equations are linear and have been estimated using ordinary least squares. The t-statistics are in parentheses.

agricultural sectors in these countries, all of which are major agricultural exporters, have been strengthened in the 1970's by the increase in the world demand for agricultural produce. Conversely, it appears that it has become increasingly uneconomic for countries with relatively low land-labor ratios who are net importers, such as Taiwan, South Korea, Egypt, and Japan, to engage in import substitution through protection and promotion of domestic agricultural production.

It also appears that countries characterized by relatively high per capita incomes have benefited from the midseventies change in the structure of world agriculture. The increase in the value of the YP coefficient suggests that, on the average, developed economies have been either importing more and/or exporting fewer agricultural goods in order to augment domestic consumption and satisfy growth in demand. Most low income countries, on the other hand, appear to have increased their net agricultural trade balances by either exporting more and/or importing fewer agricultural commodities in order to bolster deteriorating foreign exchange situations.

Countries possessing both high land-to-labor and high real-income-to-population ratios have generally experienced an unambiguous gain, on both the supply and demand side, from the change in the structure of world agriculture; while countries with low ratios are likely to have experienced net losses. There are, however, a number of countries whose attributes do not provide clear indications as to the impact on their economies of change in the structure of world agriculture. These countries are characterized by relatively high land-labor ratios and low per capita incomes (or vice-versa).

The simple aggregate trade model provided insight about some structural relationships and how they change over time. It confirmed the Heckscher-Ohlin notion that the primary factor endowment is an important explanatory consideration of agricultural trade. Moreover, it showed that real income per capita is an important determinant of agricultural trade as is suggested by neoclassical theory. The simple model, however, has limited explanatory power despite the positive results obtained. It explained only one-fourth of the variation in net agricultural trade. There are obviously many factors other than LL and YP which affect trade in agricultural commodities.

More elaborately specified aggregate trade models are suggested by Valentini and Schuh's econometric effort. Their general framework includes not only the primary factors of production in the agriculture sector (namely land and labor) but inputs which can be acquired from the industrial sector (such as fertilizer and machinery) as well as proxy measures for education and research. These additional variables represent different forms of material and human capital and render the specification of the supply portion of their trade models relatively complete. Moreover, Valentini and Schuh's framework includes, in addition to income per capita, a second domestic demand factor, population, as well as a trade balance variable designed to capture the interaction effect between the international and domestic economies.

The more sophisticated model developed in this study is similar to the Valentini and Schuh empirical framework in terms of the independent variables postulated as affecting agricultural trade.

However, the form which several of the variables takes differs from the earlier research. Furthermore, a single metatrade function is specified in this study; whereas Valentini and Schuh identified two foreign trade offer curves--one for net agricultural exporters and another for net agricultural importers. The rationale for estimating only one function as opposed to two is that growth in agriculture and economic development involve the same basic processes regardless of whether countries are net exporters or net importers of agricultural commodities. Furthermore, the attempt to build structure into the metatrade concept by estimating offer curves without introducing a second nonagricultural commodity is fraught with theoretical difficulties.

The second aggregate model estimated in this study is as follows:

$$NT = b_o + b_1\underline{LN} + b_2\underline{LB} + b_3\underline{FE/LN} + b_4\underline{ME/LB} + b_5\underline{TE/LB} + b_6\underline{GDP/POP} + b_7\underline{POP} + b_8\underline{CAP} + \xi$$

where:

NT = Real value of net agricultural trade--deflated agricultural exports minus deflated agricultural imports expressed in constant (1970) million dollar units;

LN = Area of arable and permanent cropland available for cultivation in 1000 hectare units;

LB = Active agricultural labor force expressed in millions of laborers;

FE = 1000 metric tons of plant nutrients N, P_2O_5, and K_4O;

ME = 1,000 tractor horsepower;

TE = Number of graduates from agricultural colleges equivalent to the third level of education;

GDP = Real (1970) million dollar income that has been adjusted to account for differences in purchasing power parities among countries;

POP = Millions of persons;

CAP = Value of total merchandise exports minus debt service payments plus or minus changes in reserves, expressed in real (1970) million dollar units;

ξ = Error disturbance term.

Land (LN) and labor (LB), the two primary factors of production in agriculture, are included in the empirical model to represent the natural resource endowment. Both material and human capital can be viewed as augmenting the flow of services from the natural endowment.

Fertilizer (FE) and tractor horsepower (ME) are proxies for material capital. Fertilizer represents the set of chemical-biological inputs which relax the land constraint; and horsepower represents mechanical inputs which relieve the labor constraint. Fertilizer and horsepower are incorporated in the empirical model as ratios to the primary factor for which they are basically substitutes. Thus, the fertilizer-to-land and the horsepower-to-labor are measures of factor intensity characterizing the agricultural industry. They signify technological advance from a primitive state of production to an advanced capitalized state of production.

A more intangible aspect of technological change relates to the concept of human capital. Human capital determines the capacity to effectively mobilize resources and the ability to create viable innovations. Investment in training, education, research and development is required in order to build up the human capital resource base. A proxy measure of such investment is the number of college graduates in

agriculture (TE). In the empirical model, human capital is expressed in the same way as material capital; that is, in intensity form, i.e., (TE/LB). 11/

Population (POP) and real income per capita (GDP/POP), two conventional factors affecting demand, were included in the empirical model to account for the consumption effect. A third factor, relevant to the demand for internationally traded goods, is the real capacity to pay for imports (CAP). 12/ This variable measures the availability of foreign exchange.

Estimation of the second metatrade model, presented in Table 3, provides evidence of a structural change in agriculture, confirming the results obtained from the simple model. The magnitude of the parameter estimates changed markedly from 1965 and 1970 to 1975 in both models.

An analysis of covariance was performed to verify the apparent change in structure, Table 4. The equality test for 1965 and 1970, Case 1, indicates that the structure was stable between these two periods, justifying pooling of the data to obtain more efficient parameter estimates. The statistical results for Case 2, however, provides strong evidence that structural change occurred between 1975 and the earlier 1965-70 period.

11/ Other indicators of human capital intensity, such as the primary and secondary school enrollment ratio and the literacy ratio, were originally specified in the modeling effort but were not retained because they were found to be too highly correlated with the income variable.

12/ Per capita income and capacity to pay for imports are, to a certain extent, jointly determined with the dependent variable. The possibility of serious simultaneity problems was dismissed because no significant differences were found between estimations of the metatrade model using lagged and nonlagged GDP/POP and CAP.

With pooling, greater confidence (evidenced by improved t statistics) can be placed on the parameter estimates for the 10-year data period represented by 1965 and 1970. However, the reliability of the estimated coefficients for the 1975 period are not, for the most part, as precise as for the earlier pooled period. The t statistics are particularly low for the 1975 parameter estimates of LB and TE/LB; perhaps, in part, due to relatively high degrees of collinearity between 1) labor and population and 2) among the income per capita variable and the intensity measures of machinery and human capital. The procedure of dropping the YP, ME/LB, TE/LB, variables to eliminate multicollinearity problems was disregarded in order not to introduce specification bias.

The relatively sophisticated metatrade model generated better statistical results than the simple model. Not only did the more complete model formulation identify a larger number of more significant variables but the coefficient of determination, R^2, (corrected for degrees of freedom) jumped substantially from between .25-.30 to between .77-.80. At least 20 percent of the variation in net trade still remained unexplained, however. The R^2 is very likely to increase through incorporation of additional variables; such as, a measure of capital stocks accumulated over time through investment in agriculture, improved measures for R & D activities and/or acquired human skills, and proxy measures of the infrastructure supporting agriculture and governmental policies that distort both the domestic and international factor and product markets.

Despite the statistical problems encountered, one very encouraging result of the empirical analyses was that the signs on all of the

Table 3--Time period comparisons of estimates of the international cross section aggregate agricultural trade function

Variable	1965	1970	Pooled 65-70	1975
C	148.2	181.3	221.4	615.4
LN	.0527 (8.61)	.0488 (6.16)	.0479 (9.58)	.1317 (7.26)
LB	-2.30 (-.10)	18.97 (.73)	22.64 (1.33)	29.28 (.51)
ME/LB	.0259 (.96)	.0159 (.79)	.0252 (1.63)	.0470 (1.45)
FE/LN	1404 (1.45)	1193 (1.52)	1065 (1.77)	3731 (1.98)
TE/LB	.3328 (.88)	.1414 (.64)	.2349 (1.26)	.1857 (.56)
GDP/POP	-.1092 (-.71)	-.0923 (-.63)	-.1639 (-1.58)	-.5626 (-1.73)
POP	-16.55 (-1.96)	-19.29 (-2.14)	-21.24 (-3.57)	-42.28 (-2.34)
CAP	-.2200 (-5.75)	-.1303 (-5.16)	-.1385 (-7.07)	-.2126 (-5.17)
N	57	57	114	57
R^2	.80	.78	.77	.78

Note: Equations are linear and have been estimated by ordinary least squares. The t-statistics are in parentheses.

Table 4--Stability examination of the aggregate agricultural trade function over time: An analysis of covariance

Case 1: Test of Equality Between 1970 and 1965

	Sum of squares	Number of observations
1965	$.108270 \times 10^8$	57
1970	$.149687 \times 10^8$	57
Sum	$.257957 \times 10^8$	
Pooled 1970-1965	$.304903 \times 10^8$	114
Difference	$.046946 \times 10^8$	

F_c (9,96) = 1.94

$F_{.05}$ (9,100) = 2.01

Case 2: Test of Equality Between 1975 and 1970-1965

	Sum of squares	Number of observations
1970-1965	$.0304903 \times 10^9$	114
1975	$.0949865 \times 10^9$	57
Sum	$.1254768 \times 10^9$	
Pooled 1975-1970-1965	$.2038000 \times 10^9$	171
Difference	$.0783232 \times 10^9$	

F_c (9,153) = 10.61

$F_{.05}$ (9,120) = 1.96

coefficient estimates, unlike the Valentini and Schuh study, met a priori expectations. Hence, the estimated parameters were consistent with theory and could, therefore, be used for interpretational purposes.

Standardized beta coefficients, presented in Table 5, make it possible, by normalizing different units of account, to determine the relative importance of the independent variables. It is interesting to note that the most difficult attributes for a country to alter, namely its land resource and population base, are also the most important factors in explaining net agricultural trade. A one standard deviation change in either one of these variables induces a 1.2 to 1.5 standard deviation change in net trade.

Table 5: Rank Ordered BETA Coefficients

Independent Variable	Pooled 1965-1970	1975
LN	1.41	1.47
POP	-1.39	-1.20
CAP	-.87	-.80
LB	.40	.21
ME/LB	.24	.27
GDP/POP	-.17	-.27
FE/LN	.13	.20
TE/LB	.12	.07

Population explains approximately 55 percent of the variation in net trade provided by the demand variables; while the two income variables, the capacity to pay for imports and per capita income, contribute about 45 percent. Among the supply variables, land is considered more important than capital (a summation of FE/LN, ME/LB, TE/LB); and capital is more important than the agricultural labor force. Land contributes over 60 percent of the explanation for the variation in net trade provided by the supply variables; while capital contributes between 20-25 percent and labor around 10-20 percent. The dominance of land has actually increased over time--its importance having increased slightly, at the expense of both capital and labor, between the mid-1970's and the pooled 1965-1970 period.

In addition to normalizing the beta coefficients, it is useful to evaluate the marginal value returns of the supply factors and the marginal value costs of the demand variables affecting the agricultural foreign exchange balance, all of which are expressed in real 1970 terms, Table 6. The marginal value of most factors of production employed in agriculture increased substantially between the periods represented by 1965-1970 and 1975. Agricultural labor and human capital proved to be exceptions. Skeptism is warranted in the interpretation of the change in marginal values for both of these two variables, however, because of low t statistics associated with their 1975 coefficients.

Profits tend to be capitalized into factors which are relatively fixed. In agriculture, land is generally considered to be the most supply inelastic of all resources. It is, therefore, not surprising that the empirical results show a substantial 2.5-fold increase in the returns to agricultural land between the 1965-1970 pooled period and 1975. More

Table 6--Marginal value returns (costs) of foreign exchange attributable to factors affecting agricultural trade a/

Returns (costs) per:	Pooled 1965-70	1975
Hectare of Land	$45	$118
Agricultural laborer	$13	$12
35 Horsepower tractor	$140	$246
Metric ton of fertilizer plant nutrients	$70	$236
Agricultural college graduate	$37,000	$28,000
1,000 real (1970) dollars of income	-$5	-$14
Person in population	$-15	$-19
Real (1970) disposable export dollars	-$.14	-$.21

a/ These statistics represent changes in foreign exchange associated with changes in the attributes that bear upon agricultural trade.

specifically, an additional hectare of land brought into cultivation either generated or saved, for the average country, $118 of foreign exchange in 1975 compared with only $45 in 1965-70.

There were very large expansions between 1965-70 and 1975 in the use of fertilizer and tractor horsepower, see Appendix. Fertilizer usage increased 41 percent while tractor horsepower increased 48 percent. By contrast, land and labor increased on the order of 3 and 6 percent respectively within this time frame. The expansion in the use of industrial inputs is not surprising given the growth in agricultural trade and given the relative fixity of the natural resource endowment.

The availability of land, if it is the most supply inelastic primary resource in agriculture, poses a greater restraint to increases in agricultural production than the labor resource. It is, therefore, very plausible that the returns to fertilizer, which represents the set of chemical-biological inputs that substitutes for land, have increased more rapidly than the returns to tractor horsepower, which represents the set of mechanical inputs that relieves the labor constraint. A metric ton of fertilizer brought a return of $70 to the foreign exchange balance in 1965-70. Its return more than tripled to $236 in 1975. By contrast, the gain obtained from a typical 35 horsepower tractor increased the foreign exchange balance by only $246 in 1975, not quite doubling the gain of $140 in 1965-70.

A somewhat surprising empirical finding is that the foreign exchange returns to human capital investment in agriculture dropped considerably in the mid-1970's. The value of an additional agricultural college graduate declined from $37,000 in 1965-70 to $28,000 in 1975. It is

noteworthy, however, that this decline corresponds to increases in the supply of agricultural college graduates and to the pattern of technologial change and adoption taking place in much of the world.

A major scientific breakthrough occurred in the early 1960's with the discovery of short stemmed seed varieties which were highly responsive to applications of biochemical inputs. The initial beneficiaries of this so-called "green revolution" were those countries which had not experienced impressive yield increases in their recent past and which had built up their human capital stock through investment in education, training, and R & D activities. The diffusion of the high yielding seed varieties and complementary technical packages (collectively referred to as the HYV technology) conformed, within these countries, to the "S-shaped" adoption curve. Rapid adoption of the HYV technology occurred following the period during which a few early adopters had tried the new innovation and prior to the period during which the rate of adoption tapered off.

Many developing countries substantially increased student enrollment in agricultural colleges in the late 1960's and early 1970's, perhaps in response to the high returns to human capital investment. The substantial increase in the number of agricultural college graduates worldwide is denoted by a shift to the right in the aggregate supply curve for technical education characteristic of the 1975 period.

It is, therefore, not a mere coincidence that the average payoffs to human capital fell between 1965-70 and 1975. The returns to human capital investment were particularly high during the earlier period when

the "green revolution" was taking-off. Lower returns in 1975 coincided with declining adoption rates of the HYV technology and increases in the supply of agricultural college graduates.

The empirical results conform with the a priori expectations about the consumption variables; that is, net agricultural imports increased as countries became wealthier and more populated. The marginal costs attributed to all three demand factors (income per capita, population, and the capacity to pay) increased from 1965-70 to 1975.

The marginal costs of persons in the population illustrate the foreign exchange costs of feeding an expanding population. In the 1965-70 period, each additional human being lowered the agricultural foreign exchange balance by $15. But the annual foreign exchange cost of feeding an additional person increased to $19 by the middle of the 1970 decade. These figures underscore the potential foreign exchange savings of population planning and control programs which may very well reach significant magnitudes in developing countries characterized by large populations and high population growth rates.

The empirical results suggest that net agricultural imports are very responsive to changes in individual consumers' real income. The greatest percentage increase in marginal costs generated by the model was for the income-per-capita variable. Each additional $1000 increase in real income for 1975 resulted in an average decline in the agricultural foreign exchange balance of $14 in 1975, a 280-percent cost increase from 1965-70. This large increase is explained by the pattern of demand for agricultural commodities. Income increases among poorer countries are associated with increasingly large quantities of food imports because of the relatively high income elasticity of demand for food coupled with a

relatively low elasticity of supply in agriculture. Moreover, income growth among the more developed countries results in larger agricultural imports because of the strong derived demand for animal feeds. Increases in the demand for feedgrains continue with additional increases in income for countries in the upper income categories because the demand for livestock, unlike foodgrains, is elastic.

By contrast, the percentage increase in the marginal foreign exchange costs of the capacity to pay variable was small. Twenty-one cents of each additional dollar available for imports was spent on importing agricultural commodities in 1975, while only 14 cents out of the dollar was spent on agricultural imports in the 1965-70 pooled period. This relatively small increase indicates that there is a greater degree of stability in the demand for food imports than with most other competing demands for the foreign exchange dollar.

Most countries' behavorial patterns conform to the average relationships suggested by the aggregate trade function. An examination of residual plots reveals, however, that actual trade deviated widely from fitted values for a few countries. Great Britain, for example, has consistently imported more and/or exported fewer agricultural commodities than would have been anticipated on the basis of her economic structure. This is most likely attributable to Great Britain's colonial heritage and her close ties with the Commonwealth nations with whom she established special trading relations exchanging industrial processed commodities for agricultural and raw materials.

The residual plots associated with the Netherlands, France, Brazil, and Indonesia consistently indicate that actual values of net agricultural trade exceeded fitted values. Policies exist in all of

these countries which alter the natural pattern of trade. In the Netherlands and France, the EC variable levy system protects domestic agricultural production, discouraging imports and encouraging exports. In Brazil, heavy taxes on foreign exchange as well as numerous tariffs and quotas on nonessential agricultural commodities have diminished agricultural imports, while substantial credit subsidies granted to exporters has induced increased agricultural exports. Both domestic policies, such as subsidized fertilizer and high producer support prices for rice, as well as trade policies, such as artifically high price pegs for imported wheat, have increased the net agricultural trade balance in Indonesia beyond what it would have been without government intervention.

In summary, the empirical results confirm the existence of structural change in world agriculture having occurred by the 1975 period. Both the marginal foreign exchange returns to factors of production employed in agriculture and the marginal foreign exchange costs of agricultural good consumption increased in the middle of the decade. These increases correspond with and are, in part, determined by the agricultural trade boom of the mid-1970's.

Obvious consequences of the structural shift in world agriculture are technological changes and differential returns to factors of production. In the 1960's, the payoffs to R & D activities were particularly high because of the green revolution technologies. By the mid-1970 decade, use of modern inputs associated with this revolution, such as fertilizer and tractor horsepower, increased substantially. These increases have augmented the service flows emanating from the relatively fixed, but still very important, natural resource endownment.

IMPLICATIONS FOR U.S. POLICY

The aim of the previous empirical analysis was to evaluate factors affecting trade in agricultural goods from a highly aggregative perspective. The focus, being neither country nor commodity specific, was on identification of the relative importance to average net agricultural trade of its determinants. The quantitative results generated complement and extend the findings of other researchers investigating the relationship between agricultural trade and economic development. Implications can be drawn from this entire body of knowledge about appropriate U.S. policy.

The two most important variables which explain net agricultural trade in this study are land and population, suggesting that a useful (but admittedly rather crude) indicator of agricultural comparative advantage is the land/population ratio. This finding is consistent with the fact that the United States, Australia, Canada, and Argentina--countries with high ratios of land-to-population--are major agricultural exporters possessing an obvious comparative advantage in agriculture. By contrast, most countries in Asia and Europe and many in Latin America have an apparent comparative disadvantage in agriculture because land is relatively scarce with respect to population.

Developed Country Markets and Trade Barriers

The capacity to pay for imports is the third most important variable explaining the variation in net agricultural trade. This suggests that the United States should continue to focus some attention on developed countries, mostly in Europe and Japan, where the land/population ratio is

comparatively low and where foreign exchange is relatively abundant being less of a binding constraint than elsewhere. In particular, the United States should endeavor to induce these countries to reduce their barriers on agricultural imports and subsidies on domestic production.

The econometric results demonstrated the distorting influence of policy intervention. Several European countries were specifically identified as having a pattern of agricultural trade that deviated from the structure of comparative advantage. Agricultural policies in these countries are designed to maintain farm income above levels that would exist under free trade. Economic theory presents a strong case for removal of protectionist devices which prevent the maximization of global economic welfare.

The United States would be capable of providing additional supplies of agricultural commodities efficiently in response to increased foreign demand. It stands to benefit substantially from trade liberalization unless, of course, there is a marked adverse shift in the international terms of trade. Recent history provides an example of the kind of gains to be achieved. Prior to the 1970's, the dollar was considerably overvalued causing U.S. exports to be overpriced in the international market. It has been hypothesized that measures taken to value and retain the dollar at equilibrium levels, namely the devaluation in 1971 and subsequent adoption of flexible exchange rates in 1972, contributed substantially to the expansion of U.S. agricultural exports. 13/

13/ G. Edward Schuh, "The Exchange Rate and U.S. Agriculture," American Journal of Agricultural Economics 56 (February 1974): 1-15.

Successful efforts to create a freer trade environment, particularly in Europe and Japan, are likely to result in similar increases in foreign exchange earnings.

Middle Income Countries--Fastest Growing Markets

The United States needs to cultivate trading relations with emerging middle income countries whose rate of growth in foreign exchange is increasing rapidly. Taiwan and South Korea provide examples of how agricultural imports have expanded in tandem with growth of the economy. The growth potential of agricultural import demand in countries such as Nigeria, Tunisia, Morrocco, Mexico, Brazil, Columbia, and Malaysia is substantial as the rate of increase in the demand for nontropical agricultural products is likely to outstrip growth of domestic supply. This is due to high population growth rates and relatively high income elasticities of demand for agricultural goods as well as to the transfer of resources (especially labor) out of agriculture and into industry.

Mellor contends that the income elasticity of demand for foodgrains in the middle income countries, while relatively high, is falling. 14/ He notes that the derived demand for feedgrains can stem the decline in the income elasticity of demand for total grains as countries develop. It is, therefore, very likely to be in the best interest of the United States to engage in market development activities (such as transferring known agro-industrial technologies) which encourage middle income countries to expand their poultry and livestock industries. These

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14/ John W. Mellor, "Third World Development: Food, Employment, and Growth Interactions," American Journal of Agricultural Economics 64 (May 1982): 304-311.

enterprises use feedgrains, which are tradable goods, as an input into the production of superior agricultural goods that are perishable, expensive to transport, and, therefore, difficult to exchange among countries.

Development of Markets in Low Income Countries

According to information being disseminated by the International Food Policy Research Institute, development of agriculture and rural areas in developing countries is benefitial to the United States because of the nature of demand in the Third World where three-quarters of the world's population live in developing countries characterized by high population growth rates and low levels of per capita income. 15/ The econometric results of this study lend support to this view as foreign population was shown to have a favorable impact on the agricultural foreign exchange balance for net agricultural exporters such as the United States. Moreover, we know that increases in per capita income associated with development in the Third World cause agricultural imports to rise automatically in most developing countries because of the high income elasticity of demand for food. 16/

Furthermore, Bachman and Paulino have provided evidence to assuage traditional net agricultural exporters' concern about loss of markets due

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15/ John W. Mellor, "Three Issues of Development Strategy—Food, Population, and Trade." Paper presented at the Plenary Session, "How to Go About Meeting Basic Human Needs: Developing Countries Perspective." Washington, D.C.: International Development Conference, 8 Feb. 1978.

16/ Mellor, Ibid, estimates that the income elasticity of demand for food in developing countries falls within the range of 0.7 to 1.0.

to development of food crop production in developing countries. 17/ Their analysis shows substantial increases in net imports of staple foods for developing market economies where food production has expanded faster than population.

Moreover, most developing countries, by virtue of their geo-climatic and geo-demographic situation, have a comparative advantage in such agricultural products as tropical fruits, coffee, cocoa, palm oil, rubber, cassava, and sorghum--none of which are produced in any significant quantities by developed countries in the temperate zone. It is partly for this reason that increases in the agricultural production capacity of developing countries often results in an expansion of both agricultural exports and agricultural imports.

The major dilemma concerning U.S. agricultural development and commercial policy vis-a-vis the low income countries is not whether their growth results in the production of commodities that compete unfavorably with goods produced in the United States, but rather how these countries, caught in the viscious cycle of poverty, can develop and how real per capita incomes can increase. A key issue determining appropriate U.S. policy toward individual low income countries is where their comparative advantage lie given existing resources and likely investment patterns.

Whether or not a focus on agriculture would be preferable over an emphasis on nonagricultural activities depends upon the relative social costs and social returns of feasible alternatives. According to Mellor

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17/ Kenneth L. Bachman and Leonardo A. Paulino, "Rapid Food Production Growth in Selected Developing Countries: A Comparative Analysis of Underlying Trends, 1961-76." Research Report No. 11 (Washington D.C.: International Food Policy Research Institute, October 1979).

and Lele, the social rate of return of investment in agriculture among the low income countries is generally higher than outside of agriculture for two reasons: 1) there is usually a limited capacity to absorb labor in sectors outside of agriculture and 2) there is often an agricultural wage good constraint to nonagricultural development. 18/ Increased investment in agriculture relaxes this wage good constraint through labor mobilization via real wage rate increases. Hence, agricultural investment in developing countries fosters not only agricultural development but general economic growth as well.

The United States stands to reap long-run gains from promoting general economic development in low income countries, especially where there is an export potential. The existence of an outlet for surplus production in developing countries generates additional employment and higher incomes--a large proportion of which will presumably be used to increase imports of many agricultural goods for which the United States has a comparative advantage. Increased foreign exchange and growth of incomes in low income countries stimulates the import demand for wheat and other foodgrains and then, later, augments the derived import demand

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18/ The agricultural wage good constraint refers to the high percentage of nonagricultural income spent on food which makes industrial work unattractive. Mellor and Lele contend that low income laborers spend as much as 60 percent of increments to their income on food grains and 80 percent on all agricultural commodities. For further discussion on the agricultural wage good constraint see John W. Mellor and Uma Lele, "The Interaction of Growth Strategy, Agriculture, and Foreign Trade: The Case of India," in Trade, Agriculture, and Development, ed. George J. Tolley and Peter A. Zadrozny (Cambridge: Ballinger Publishing Co., 1976), pp. 93-113; Avinash K. Dixit, "Marketable Surplus and Dual Development." Journal of Economic Theory 1 (June 1969): 203-219; and J.M. Hornby, "Investment and Trade Policy in the Dual Economy," Economic Journal 78 (March 1968): 96-107.

for feedgrains because of the desire to improve dietary patterns with increased meat and meat byproducts consumption.

The empirical results of this study confirm the existence of a wide technological gap separating the agricultural economies of the developed from the developing countries. On the basis of both future market extensions and humanitarian concerns, the United States should take measures to close this gap through involvement in agricultural development in developing countries. Low income countries need support, in particular, for infrastructure, research and training activities--from which originate capital accumulation. Increased focus on infrastructure would eliminate bottlenecks enabling the market system to operate more efficiently. A greater emphasis on R & D would facilitate additional transfer, adaptation, and creation of technologies suitable to the unique conditions confronting the developing countries rendering them more competitive with the outside world.

Under certain conditions commercial as well as concessional food imports can assist the development process in low income countries. Food imports may relieve, at relatively low costs, the agricultural wage good constraint and thereby induce labor to transfer to the nonagricultural sector. Moreover, such imports could enable developing countries to pursue efficient as well as equitable development strategies provided, however, there are possibilities for productivity increases and employment opportunities outside of agriculture.

Modern agricultural technologies often have distribution biases. It is for this reason that Hayami and Ruttan have recommended that an efficient agricultural development strategy for developing countries

characterized as being relatively land scarce and labor abundant is to promote the use of inputs which are land augmenting such as fertilizer and biochemicals. 19/ The alternative approach of emphasizing machinery would not only be inefficient but would likely widen income differentials within the agricultural sector.

While a land augmenting development strategy may make sense for the agricultural sector, it could, however, be detrimental to the overall growth of the economy. Lele and Mellor point out that a relatively small marketable surplus is likely to be generated in agriculture with the implementation of high employment policies because farmers in low income countries consume a large proportion of their incremental production due to the high income elasticity of demand for food. 20/ Furthermore, there may be little stimulation for growth in nonagricultural production through promotion of high employment strategies in agriculture because the rural labor force may become more supply inelastic while increasing its product share.

Whether concessional food imports assist development or detract from it depends upon specific circumstances. In the event that long run comparative advantage for developing countries lie in agriculture, food aid is likely to provide (unless restricted to emergency needs) strong disincentives to agricultural production, diminishing economic

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19/ Yujiro Hayami and Vernon W. Ruttan, Agricultural Development: An International Perspective (Baltimore: Johns Hopkins Unviversity Press, 1971).

20/ Uma Lele and John W. Mellor, "Technological Change, Distributive Bias and Labor Transfer in a Two Sector Economy," Oxford University Papers 33 (November 1981): 426-441; John W. Mellor and Uma Lele, "The Interaction of Growth Strategy, Agriculture, and Foreign Trade: The Case of India," in Trade, Agriculture, and Development, ed. George J. Tolley and Peter A. Zadrozny (Cambridge: Ballinger Publishing Co., 1976), pp. 93-113.

development and growth. Concessional food imports tend to decrease agricultural laborers' product share because farmer profits are squeezed by subsidized foreign competition. Labor is, therefore, induced to leave agriculture, decreasing food production in the intermediate run and possibly stifling future exploitation of complementary agricultural resources.

On the basis of the land-to-population criterion of comparative advantage, many countries in Africa may very well have a favorable comparative cost structure in agriculture, especially with respect to the rest of the developing world. 21/ The land/population ratios characterizing many African countries are higher than in most of Asia and Latin America. Furthermore, the disparity in the land/population ratios in the developing world are likely to increase because of relative high population growth in Asia and Latin America and because of the possibility that technological advance will enable land, presently characterized as having low productivity in Africa, to realize its agronomic potential.

21/ Africa's long run comparative advantage in agriculture may be overstated because of the way in which land is defined. In this study, agricultural land is equivalent to the FAO measure of "available arable and permanent cropland." However, certain (but admittedly very crude) distinctions in land quality and geoclimatic considerations are embedded in this definition of agricultural land, for nonarable land considered ill suited for cultivation as well as permanent pasture and woodlands are not included in the measure of available arable and permanent cropland. Furthermore, attempts were made in Rome to make the figures on arable and permanent cropland reasonably consistent. The land data for many African countries were adjusted downward from what was reported because of lengthy fallow periods characteristic of "slash and burn" agricultural practices. Comparison of the land resource base across countries using a broad definition of land has, nevertheless, inherent problems. Therefore, the land/population criterion denoting comparative advantage in agriculture may be misleading in some cases.

The empirical results suggesting that Africa might have a comparative advantage in agriculture relates to the long run and is, therefore, subject to uncertainty. The pattern of comparative advantage changes over time and is determined not only by the natural resource endowment but also by technological development and capital investments in all kinds of economic activities. At present, Africa does not have a comparative advantage in agriculture with respect to the primary net agricultural exporting countries because of market deficits (lack of marketable surplus) and inadequate investment in agriculture. The productivity of land in Africa is often low due to the absence of sufficient complementary factors, namely human knowledge, irrigated water, fertilizer, machinery and other land and labor augmenting capital inputs which increase the returns to agriculture. However, should all countries make the same kind of R & D and capital investments in agriculture typical of previous patterns in the rest of the world, ceteris paribus, many countries in Africa are likely to eventually emerge with a clear cut comparative advantage in agriculture. There are, however, risks associated with such investment. Technological progress, which provides viable economic solutions to specific problems that presently constrain productivity of African agriculture--such as arid conditions and low quality soils--may never be forthcoming.

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Appendix

This appendix is comprised of data (on 57 countries for 1965, 1970, and 1975) utilized in the previous intercountry analyses. Annual data on most of the variables herein contained will soon be available in six forthcoming ERS Staff Reports entitled "Selected Socioeconomic Development Indicators" concentrating on different geographical regions.

In general, five year averages were used in the econometric analysis of this report in order to mitigate stochastic and reporting errors. Thus, for example, net agricultural trade, fertilizer, and other flow variables were calculated, respectively, as 1963-67 averages, 1968-72 averages, and 1973-77 averages. However, stock variables, such as agricultural labor and technical education, were measured differently. The size of the agricultural labor force were point estimates for 1965, 1970, and 1975. Technical education, being a cumulative concept, was measured as a 15 year average of the number of college graduates in agriculture.

Brief variable definitions and data sources are contained in the following tables and their footnotes. Country analysts within ERS provided supplementary information when data were not available from the primary sources. Amjad Gill proved particularly helpful in securing Taiwanese data not published by either UN or FAO.

Table 1

Country	1965 Exports	1965 Imports	1970 Exports	1970 Imports	1975 Exports	1975 Imports
	100,000 U.S. Dollars (1970 value)					
Argentina	13420	914	13006	1167	34764	2325
Australia	25712	2305	26373	2780	67428	6461
Austria	871	3492	1314	4127	2941	10066
Bel.-Lux.	8051	11673	12271	16976	27503	44615
Brazil	12604	2724	18692	3169	67054	9870
Burma	1802	410	922	915	1255	217
Cameroon	948	179	1304	285	3474	675
Canada	15832	8901	17307	12104	42755	33583
Chile	347	1595	345	1802	1395	4048
Colombia	3892	595	5163	771	14744	1943
Costa Rica	997	107	1598	314	4813	717
Cyprus	375	271	633	372	1251	1060
Denmark	11106	4481	11605	5996	27591	13592
Dominican Rep.	1361	325	1911	368	6183	1319
Ecuador	1012	197	1736	217	4670	754
Egypt	3926	3245	4959	2815	9685	11172
Finland	777	2228	1173	2522	2654	6414
France	17739	20229	29754	32464	75846	83153
Germany (Fed. Rep.)	5547	44481	11877	62917	40672	144818
Great Britain	16103	57823	12903	57921	30433	109635
Greece	2743	1790	2945	2330	6620	6260
India	7404	9397	7859	5755	19065	13917
Indonesia	4132	902	5178	2448	13186	6248
Iran	899	1200	1444	1851	3296	15044
Iraq	369	997	853	1247	694	6551
Ireland	3869	2030	4735	2347	11086	5726
Israel	1166	1661	2229	2266	4630	6479
Italy	8603	23494	13258	33810	20478	81815
Jamaica	918	615	748	798	1765	1790
Japan	2037	29549	3318	44198	4481	117811
Kenya	1252	452	1566	428	4377	796
Korea (Rep.)	416	1509	911	4210	3822	13612
Madagascar	700	704	1012	746	2024	509
Malaysia	5994	3062	8154	2891	23142	7778
Mauritius	633	256	649	275	2134	871
Mexico	5602	1076	6884	1696	13868	7679
Morrocco	2005	1611	2396	1068	4108	6171
Netherlands	17490	12958	28124	26616	73957	58902
New Zealand	10622	927	11235	946	24086	2339
Nigeria	3771	778	3476	1114	5137	7925
Norway	868	2604	917	2987	1654	7383
Pakistan	5505	4107	4773	3474	6023	8877
Peru	1668	1184	1586	1260	4081	2812
Philippines	5135	1701	5576	1632	15092	3515
Portugal	1228	2207	1614	3252	2934	10199
South Africa	5446	1796	6141	2433	13383	4777
Spain	4443	6526	6930	9232	16236	27445
Sri Lanka	3890	1752	3574	1521	5367	3014
Sudan	10622	927	11235	946	24086	2339
Sweden	1657	5653	1961	7393	4582	16167
Switzerland	1771	6916	2069	6997	5196	19815
Taiwan	2541	3752	3945	9641	10811	44717
Thailand	5207	865	6361	996	20894	2044
Tunisia	635	546	766	801	1635	2458
Turkey	3885	714	5152	561	12075	2016
United States	59975	85369	73633	61419	210061	137264
Venezuela	358	1608	366	1959	808	7207

Source: FAO, Trade Yearbook (various issues), UN trade data tapes available in ERS, and agricultural export and import deflators obtained from FAO, State of Food and Agriculture (various issues).

Table 2

Country	Arable and Permanent Cropland			Active Agricultural Labor Force		
	1965	1970	1975	1965	1970	1975
	1,000 Hectares			1,000 Persons		
Argentina	29418	33422	34620	1572	1506	1427
Australia	37828	41032	41720	459	434	398
Austria	1645	1679	1616	626	468	380
Bel.-Lux.	943	922	898	245	186	152
Brazil	51378	54252	56794	12737	13705	14524
Burma	10340	10420	9962	7144	7068	7154
Cameroon	5734	5998	6398	2315	2434	2987
Canada	42053	41958	43352	766	705	614
Chile	4443	4496	5209	727	685	667
Colombia	5052	5201	5327	2276	2392	2276
Costa Rica	885	893	898	208	224	244
Cyprus	432	432	432	104	99	104
Denmark	2722	2681	2600	310	254	212
Dominican Rep.	1050	1130	1197	651	743	813
Ecuador	2529	2555	2607	882	902	1039
Egypt	2601	2837	2838	4822	5068	5417
Finland	2538	2529	2507	603	459	376
France	20493	18998	18823	3068	2876	2429
Germany (Fed. Rep.	7735	7608	7570	2902	2801	1543
Great Britain	7442	7258	7047	808	728	618
Greece	3845	3929	3878	1946	1720	1562
India	162612	164780	167867	142968	153522	161407
Indonesia	17172	18127	19331	25123	27907	29285
Iran	15446	15649	15894	3361	3780	3920
Iraq	4900	5065	5204	1048	1123	1200
Ireland	1254	1139	1011	349	296	279
Israel	407	413	419	119	104	102
Italy	12878	12734	12279	5023	3756	3033
Jamaica	239	218	201	216	186	168
Japan	5850	5476	5045	12921	10492	8516
Kenya	1832	2004	2232	3176	3759	4242
Korea (Rep.)	2233	2288	2256	5636	5599	5672
Madagascar	2243	2378	2673	2879	3175	3356
Malaysia	3700	3950	4196	1791	1962	2096
Mauritius	94	105	104	85	87	93
Mexico	23473	23190	23209	6292	6555	6914
Morrocco	7218	7480	7700	2171	2267	2441
Netherlands	901	872	848	426	398	342
New Zealand	517	538	413	132	130	129
Nigeria	29169	29706	30030	13467	14145	14826
Norway	846	817	794	225	175	146
Pakistan	27967	26326	26852	27168	30493	33365
Peru	2586	2935	3261	1686	1700	1859
Philippines	6381	9554	9748	6628	7374	7685
Portugal	4162	3775	3619	1368	1163	1088
South Africa	13168	14329	14496	2073	2570	2817
Spain	20499	21411	20792	3960	3952	3832
Sri Lanka	1847	1979	2001	2107	2368	2564
Sudan	11209	11709	12168	3075	3703	4216
Sweden	3234	3044	3008	379	298	235
Switzerland	404	387	342	256	235	198
Taiwan	880	904	915	1868	2113	2367
Thailand	12797	13859	16599	12131	13307	14654
Tunisia	4348	4403	4803	630	605	601
Turkey	26129	27512	27962	10692	10567	10502
United States	185102	192140	189163	4050	3197	2598
Venezuela	3489	3502	3577	813	776	801

Source: FAO, Production Yearbook (various issues).

Table 3

Country	Total Fertilizer Consumption 1/			Tractor Horsepower 2/		
	1965	1970	1975	1965	1970	1975
	1,000 Metric Tons			1,000 Horsepower		
Argentina	42	80	75	5634	7790	9370
Australia	1015	4073	1044	9491	14629	16693
Austria	354	409	365	3922	8838	11758
Bel.-Lux.	481	516	495	2217	3285	4268
Brazil	286	996	2200	2364	4564	9671
Burma	13	35	51	109	185	316
Cameroon	9	16	18	1	3	11
Canada	690	829	1323	24549	27253	31063
Chile	117	150	140	734	1018	1120
Colombia	141	165	255	940	969	1082
Costa Rica	34	51	64	133	188	224
Cyprus	17	27	20	142	241	391
Denmark	493	608	658	4861	6124	7490
Dominican Rep.	13	43	79	57	150	154
Ecuador	22	40	62	58	104	206
Egypt	298	367	472	330	621	856
Finland	332	476	507	3819	6269	8366
France	3251	4636	5101	25934	51204	62800
Germany (Fed. Rep.)	2777	3122	3265	23782	48094	58040
Great Britain	1614	1799	1863	11598	16193	19372
Greece	250	337	466	1467	2315	4041
India	905	2247	3201	1587	3204	9192
Indonesia	113	273	491	34	304	416
Iran	44	127	342	180	805	1472
Iraq	5	17	39	266	360	647
Ireland	260	422	479	1895	2926	4484
Israel	40	50	69	317	565	806
Italy	1026	1344	1465	12943	22570	34290
Jamaica	19	22	18	118	224	176
Japan	1975	2134	2103	29431	28098	34400
Kenya	25	45	51	183	225	236
Korea (Rep.)	391	564	770	4	73	484
Madagascar	6	12	9	20	83	97
Malaysia	63	164	271	5	107	239
Mauritius	23	24	25	8	10	12
Mexico	363	578	981	1738	3381	5560
Morrocco	53	101	163	327	535	785
Netherlands	564	606	636	2234	5407	6623
New Zealand	37	42	49	2967	3360	3851
Nigeria	5	11	50	13	72	300
Norway	168	197	226	2250	3695	4879
Pakistan	166	413	767	50	687	1529
Peru	90	87	122	300	388	496
Philippines	104	191	255	163	193	422
Portugal	166	175	242	489	992	1652
South Africa	350	577	773	5100	6015	7068
Spain	622	1242	1504	4546	10701	17722
Sri Lanka	77	91	101	51	262	629
Sudan	34	81	64	81	160	350
Sweden	382	495	527	6985	6648	8366
Switzerland	129	144	151	1438	3097	3603
Taiwan	227	263	320	61	107	254
Thailand	53	115	209	93	219	1052
Tunisia	22	35	48	421	677	1050
Turkey	165	477	915	1590	3746	9634
United States	11409	15218	18213	146708	203315	222070
Venezuela	42	62	152	467	665	1035

1/ Consumption of nitrogenous, phosphate and potash fertilizer in plant nutrient equivalent. Source: FAO, Annual Fertilizer Review (various issues), and data printouts obtained from the FAO, regional office in Washington, D.C., and secondary data sources obtained from country analysts within the International Economics Division of ERS.

2/ Source: FAO, Production Yearbook, various issues.

Table 4

Country	Agricultural College Graduates 1/			Real Gross Domestic Products Per Capita 2/		
	1965	1970	1975	1965	1970	1975
				1970 U.S. Dollars		
	301	466	726	1687	2910	4201
Argentina	379	624	907	2772	3339	3686
Australia	169	195	212	2936	2998	3057
Austria	223	283	300	2828	3884	4232
Bel.-Lux.	530	1044	1900	862	1116	1501
Brazil	170	216	236	197	260	313
Burma	5	8	25	317	407	450
Cameroon	574	738	1138	3317	3978	4736
Canada	116	239	402	1645	1854	1767
Chile	104	298	596	720	840	1029
Colombia	9	12	17	948	1124	1335
Costa Rica	10	11	11	1168	1442	1538
Cyprus	177	218	231	2964	3557	4046
Denmark	15	15	16	676	750	1016
Dominican Rep.	38	109	195	594	671	840
Ecuador	1664	2734	4471	477	506	509
Egypt	148	205	227	2317	2954	3577
Finland	693	774	776	2767	3492	4101
France	1068	1200	1494	3942	3673	4215
Germany (Fed. Rep.)	649	923	1274	2748	3948	3389
Great Britain	126	273	432	1340	1859	2348
Greece	4632	6956	8390	295	318	328
India	777	1192	1625	206	254	310
Indonesia	137	382	647	619	850	1374
Iran	77	191	420	752	749	873
Iraq	143	171	191	1657	2029	2795
Ireland	75	118	207	2024	2694	3193
Israel	592	841	934	1486	2378	2648
Italy	37	45	50	998	1351	1739
Jamaica	7267	9260	11691	1862	2956	3505
Japan	16	20	278	205	364	335
Kenya	1834	2725	4259	430	616	892
Korea (Rep.)	3	16	25	291	327	790
Madagascar	55	121	212	679	767	996
Malaysia	27	32	56	622	665	909
Mauritius	164	217	334	1044	1235	1379
Mexico	24	35	50	545	699	682
Morrocco	415	555	827	2607	3247	3747
Netherlands	227	388	525	2946	3164	3434
New Zealand	42	141	197	2788	319	418
Nigeria	109	146	169	2847	3367	4028
Norway	502	693	1230	771	838	849
Pakistan	213	553	674	1009	1068	1175
Peru	830	934	2218	540	573	670
Philippines	55	69	190	909	1205	1550
Portugal	145	367	710	1106	1347	1496
South Africa	254	234	398	1498	1905	2300
Spain	8	18	35	372	837	535
Sri Lanka	37	109	241	818	802	828
Sudan	160	223	287	3517	4044	4832
Sweden	47	69	139	3212	3495	3692
Switzerland	729	1327	1787	1729	2306	2869
Taiwan	409	519	635	367	459	505
Thailand	26	73	94	502	693	937
Tunisia	507	667	705	743	868	1104
Turkey	8606	11622	17413	4361	4882	5353
United States	68	156	340	1781	1873	1781
Venezuela						

1/ Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO), Statistical Yearbook, various issues.

2/ Source: Summers, Robert; Kravis, Irving B., and Heston, A. Alan, "International Comparison of Real Product and its Composition: 1950-77." Review of Income and Wealth, (March 1980): 19-66.

Table 5

Country	Population 1/			Real Capacity to Pay for Imports 2/		
	1965	1970	1975	1965	1970	1975
	10,000			Million U.S. Dollars (1970 value)		
Argentina	2190	2375	2534	1330	1222	1709
Australia	1130	1258	1375	3244	5405	5717
Austria	725	743	752	1750	2433	4167
Bel.-Lux.	952	1000	1015	7000	9352	16017
Brazil	8989	9265	10631	1320	2472	3567
Burma	2468	2705	3016	203	93	90
Cameroon	530	570	754	150	167	284
Canada	1969	2130	2270	9012	16462	17600
Chile	850	937	1027	672	849	866
Colombia	1798	2055	2367	470	641	797
Costa Rica	149	174	196	117	197	260
Cyprus	54	61	62	85	143	184
Denmark	476	493	506	2482	3433	4499
Dominican Rep.	351	400	470	157	214	344
Ecuador	506	597	707	181	200	529
Egypt	2901	3329	3718	500	550	584
Finland	456	466	471	1464	2297	2990
France	4872	5379	5200	10019	18090	26499
Germany (Fed. Rep.)	5685	6080	6175	19480	36040	50911
Great Britain	5417	5543	5584	14170	19977	24133
Greece	857	880	900	363	704	1039
India	48292	53932	60081	1519	1060	2323
Indonesia	10518	11952	13520	659	1126	3029
Iran	2483	2879	3290	1369	2513	10330
Iraq	806	945	1117	941	1175	4217
Ireland	287	296	317	727	1026	1749
Israel	255	297	345	435	731	953
Italy	5195	5360	5575	7713	13400	18164
Jamaica	176	187	204	234	396	501
Japan	9885	10447	11141	16880	22515	30983
Kenya	956	1127	1340	187	225	321
Korea (Rep.)	2940	3270	3527	232	765	3038
Madagascar	807	882	768	97	131	134
Malaysia	925	1044	1195	1394	1657	2384
Mauritius	75	81	80	70	81	135
Mexico	4272	5072	6027	922	1210	1127
Morrocco	1346	1508	1732	400	489	684
Netherlands	1429	1393	1365	6782	12204	18792
New Zealand	263	282	305	1080	1405	1371
Nigeria	4870	5028	6574	650	1282	4736
Norway	372	380	401	1599	2547	3749
Pakistan	10242	11750	14853	476	550	711
Peru	1165	1345	1548	677	639	504
Philippines	3189	3685	4254	838	1072	1309
Portugal	878	890	938	670	868	990
South Africa	1920	2247	2555	1707	2290	2425
Spain	3200	3378	3569	1047	3011	4130
Sri Lanka	1117	1245	1351	385	302	267
Sudan	1320	1410	1582	188	255	232
Sweden	773	803	819	4202	6097	8906
Switzerland	585	620	634	3360	4893	7619
Taiwan	1295	1497	1643	551	1033	3209
Thailand	3092	3032	4187	737	757	1340
Tunisia	463	513	564	118	190	385
Turkey	3122	3525	4015	399	722	746
United States	19414	20433	21337	29797	40760	53080
Venezuela	871	1028	1200	2917	2871	5145

1/ Source: Bureau of Statistics of the International Monetary Fund, International Finance Statistics, various issues.

2/ Real value of total merchandise exports of goods and nonfactor services plus net change in international reserves minus debt service payments. Source: Derived from FAC data on the total value of merchandized exports, IMF data on international reserves, a combination of OECD and World Bank data on debt service payments, and World Bank indices of international inflation.

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